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Public Health Service
Consumer Protection and Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 8, August 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Environmental Control Administration • Bureau of Radiological Health

Reports

Environmental Surveillance Around A Nuclear Fuel Reprocessing Installation, 1965-1967

William J. Kelleher[1]

A summary report of environmental surveillance around a nuclear fuel reprocessing plant is presented. This report includes data obtained before and after the plant began operations in April 1966. Media monitored included air and milk supplies in the surrounding area; liquid wastes; local watersheds and streams; silt, deer, and fish in the plant perimeter area. Data obtained through 1967 indicate that the discharges from the plant stack have not produced environmental effects from particulate beta-particle emitters or iodine-131 that might constitute a public health hazard. Surveillance of the streams showed greater concentrations of strontium-90 during the fall and winter of 1966–1967 than in the latter part of 1967. Silt removed more cesium-137 than strontium-90; most of the latter was in the dissolved state. The ratio of cesium-137 to cesium-134 (cesium-134 is indicative of spent fuel) in the wastes was about 4 or 5 to 1. The levels of radioactivity in deer and fish were sufficiently high to require careful evaluation of the public health significance.

Spent fuel from nuclear reactors is processed by Nuclear Fuel Services, Inc. (NFS) on a 3,300 acre State-owned site, 30 miles southeast of Buffalo, in the town of Ashford, Cattaraugus County, New York. The company operates under a license from the Atomic Energy Commission (AEC) and is allowed to discharge radioactive materials to the atmosphere and to local water courses. The 3-year surveillance program (1965–1967) includes data obtained before and after the plant started to reprocess fuel elements in April 1966.

The location of the site and its relation to Cattaraugus and Buttermilk Creeks is shown in figure 1. Atmospheric discharges from the plant are through a 200-foot-high stack at an air-flow rate of 40,000 to 45,000 cfm. Permitted discharges are: krypton-85, 12,600 curies per day; iodine-131, 3.3 curies per year; gross alpha and gross beta

Figure 1. Nuclear Fuel Services environs; open reservoirs, impounding reservoirs, and watersheds of public water systems

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radioactivity on particulates, 0.1 microcuries per second (*1*).

The liquid wastes are continuously monitored while passing into one of two intercepting tanks. After laboratory analysis, the tank content is drained into the first of three holding lagoons or is pumped back to the plant for evaporation and storage. The holding lagoons are in series and provide 40 to 120 days of storage depending on liquid-waste flow. The third lagoon is routinely analyzed and discharges are made at a rate such that concentrations after dilution in Cattaraugus Creek averaged for the year will not exceed the concentrations set forth in the Code of Federal Regulations 10-CFR-20[2] for releases to unrestricted areas, and at any time shall not exceed twice these concentrations (*1*). Each day, the flow in Cattaraugus Creek is determined and the release rate from lagoon 3 (controlled by a V-notch weir) is regulated.

Discharge of the waste is to Franks Creek, which flows into Erdman Brook, to Buttermilk Creek, to Cattaraugus Creek, and thence to Lake Erie. The State-owned site includes a small section of Cattaraugus Creek on both shores where Buttermilk Creek enters Cattaraugus Creek. Although the waste is diluted as it flows into the different streams, there are approximately 2 miles of Buttermilk Creek and 1 mile of Erdman Brook and Franks Creek on the site where concentrations are much greater than the 10–CFR 20–limits.

The waste lagoons and the contaminated sections of Buttermilk, Franks, and Erdman Creeks are accessible to deer for drinking. Migratory fish such as suckers can swim up Buttermilk Creek beyond the entrance of Erdman Brook.

Another source of liquid waste is from two holding lagoons at the burial site located upstream from the reprocessing plant on Franks Creek. Rain water that has entered an open trench is pumped into a holding lagoon in order to provide dry working conditions in the open end of the trench. Radioactive materials from previously deposited crushed containers are leached out and significant concentrations of various radionuclides have been found in the holding lagoons. These radionuclides are pumped into Franks Creek at a controlled rate after analysis.

The revised safety analysis report (*2*) submitted by the company in August 1964, estimated that the gross radioactivity in Cattaraugus Creek would be about 0.1 pCi/liter, exclusive of tritium. The surveillance program of the State Health Department initially concentrated on vectors affected by airborne releases originating from the stack. A single water sampling station was established on Cattaraugus Creek as a check on operations. It was not originally planned to do extensive studies on wildlife, fish, and silt, because at the concentrations predicted in the saftey analysis, the possible reconcentration of radioactivity in fish and wildlife was not expected to be a problem.

The company first started to dissolve fuel in April 1966, beginning with fuel that had little burn-up and progressing to spent fuel with more normal burn-up by August 1966. Beginning in September 1966, curie quantities of radioactive materials were being discharged to Franks Creek each month.

Effects of stack discharges

In order to determine the possible effects of stack discharges on the environment, the State Health Department has monitored air and milk supplies in the surrounding area and has reviewed the stack discharges reported by the company. In addition, gamma radioactivity has been meas-

Table 1. Gross beta radioactivity in air particulate samples, 1965–1967

Site number		Concentration (pCi/m^3)		
		1965	1966	1967
20	Average	<1	<1	<1
	Maximum	<1		
12	Average	<1		
	Maximum	<1		
2	Average	<1		
	Maximum	1		
11	Average	<1		
	Maximum	1		
4	Average		<1	<1
	Maximum		<1	<1
14	Average		<1	<1
	Maximum		<1	<1
43	Average		<1	<1
	Maximum		<1	<1
44	Average		<1	<1
	Maximum		1	<1
45	Average		<1	<1
	Maximum		1.1	1
Statewide: [a]				
	Average	<1	<1	<1
	Maximum	2	2	1.5

[a] Excludes samples from NFS area.

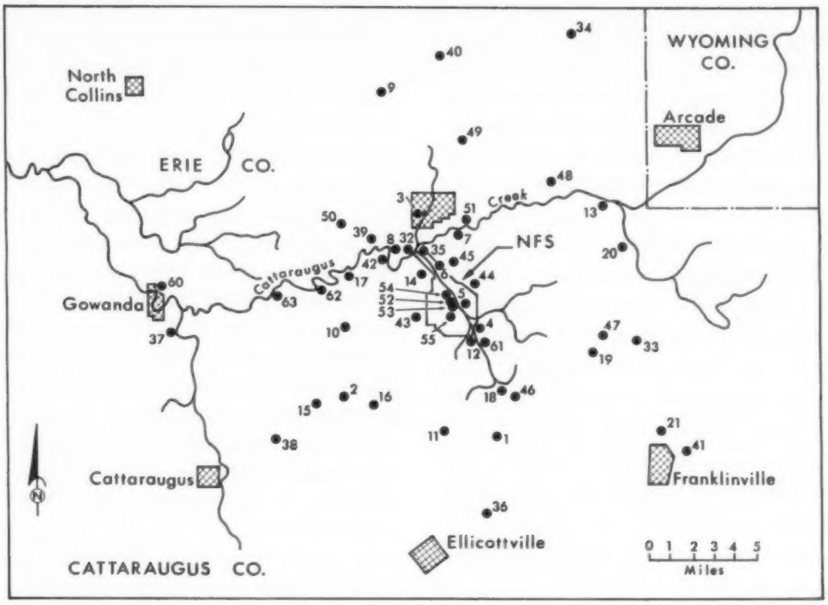

Figure 2. New York State Surveillance Program for Nuclear Fuel Services Facility, site numbers, and locations, 1965–1966

ured at 30 different sites, using a pressurized ionization chamber. The locations of the sampling stations by number are shown in figure 2.

Air samples are taken continuously at 5 different locations for a 7-day period, using a 2-inch glass-fiber filter at an air-flow rate of 1.1 cfm. These samples are analyzed for gross beta radioactivity. In the statewide surveillance program, a value below 1.0 pCi/m³ was not considered significant because of fluctuations in fallout caused by occasional atmospheric weapons test. The decline in fallout as a result of the limited test-ban treaty has allowed better comparisons of air concentrations below 1.0 pCi/m³. A summary of the air results and a comparison with the statewide average is given in table 1. Table 2 presents a summary and an explanation of air results greater than 0.3 pCi/m³ for the NFS site for the years, 1966–1967. If reasonable dilution factors for each site are considered, the volume of air sampled is not large enough to provide the sensitivity required to detect the maximum rate of particulate radioactivity that is allowed to be discharged.

[2] Title 10, Part 20 of the Code of Federal Regulations.

Table 2. Radioactivity is air samples at Ashford, N.Y. 1966–1967

Site number and location		Collection dates	Gross beta (pCi/m³)	Explanation
		1966		
4	Buttermilk Creek at Fox Valley Road bridge	6/22– 6/28	0.37	(a)
		8/24– 8/30	.32	(b)
		11/ 9–11/15	.34	(c)
		11/16–11/22	.34	(c)
14	Walter Feuz farm near Edies siding	6/10– 6/16	.55	(a)
		6/17– 6/23	.55	(a)
43	Harmon Houri's farm 2 miles S.W. of NFS	8/16– 8/22	.33	(b)
		11/ 8–11/14	.69	(c)
44	Devere Zefer's farm on county road 32, 1.5 miles north of Riceville	11/ 3–11/ 9	1.03	(c)
		11/10–11/16	.32	(c)
		12/ 1–12/ 7	.32	(c)
45	Robert Emerson's farm on Thomas Corners Road	6/25– 7/ 1	.47	(a)
		11/ 4–11/10	1.12	(c)
		11/19–11/25	.88	(c)
		1967		
14	Walter Feuz farm	12/14–12/21	.33	(d)
43	Harmon Houri farm	12/19–12/21	.53	(d)

[a] A Chinese nuclear explosion in the atmosphere occurred on May 9, 1966.
[b] A French atmospheric nuclear explosion occurred in the Atolls on May 2, 1966.
[c] A Chinese atmospheric nuclear test occurred on August 28, 1966.
[d] The Environmental Radiation Surveillance Report No. 5, March 11, 1968 prepared by the Standards and Intelligence Branch, National Center for Radiological Health, PHS, showed that during the period, December 12–21, 1967, slightly higher than normal readings occurred at many of the air sampling stations in the United States. It is believed that the slightly higher readings found in the NFS area were caused by residual radioactivity in the atmosphere from weapons testing and not from stack discharge.

However, past experience in the State with fallout from weapons testing indicates that this method of air sampling is sensitive enough to predict significant increases in the strontium-90, cesium-137, and possibly iodine-131 in the milk of cows grazing on land on which the radioactivity may accumulate.

The average and maximum values for milk samples taken in 1965 through 1967 for the NFS area are given in table 3; the statewide values are also shown for purposes of comparison. The iodine-131 data indicate no detectable releases. This result was expected since most of the fuel elements processed were aged. Starting in 1967, an ion exchange procedure and separate counting for iodine-131 was adopted for milk, but even with the more sensitive procedure, the presence of iodine-131 in milk attributable to discharges from NFS was not detected.

The cesium-137 and strontium-90 in cows' milk from individual herds in the NFS area were not of high enough concentration to indicate that stack discharges made any detectable contributions of these radionuclides to the milk. For comparison with other sample taken in the State, it should be noted that individual herds were sampled in the NFS area, while most statewide samples were composited. Even before operations were started at the plant, some farms in the NFS area showed higher strontium-90 and cesium-137 concentrations in the milk than did most stations in the State. This is probably attributable to differences in farming practices (*3*).

Background gamma radioactivity readings were taken at 30 different sites in the NFS area in 1964, utilizing a Reuter-Stokes RSG-9 pressurized ionization chamber (*4*). In 1967, repeat readings were made and compared with concurrent values in other areas of the State. The 1967 data indicate

Table 3. Milk samples, 1965–1967

Location site number		Concentration (pCi/liter)								
		1965			1966			1967		
		^{90}Sr	^{131}I	^{137}Cs	^{90}Sr	^{131}I	^{137}Cs	^{90}Sr	^{131}I	^{137}Cs
2	Average	NS	NS	NS	12.5	<20	20.5	11	<5	16
	Maximum	NS	NS	NS	18.0	<20	53.0	16	6	25
13	Average	25.5	<20	74.4	20.0	<20	31.2	12	<5	20
	Maximum	34.0	<20	86.1	27.0	49.3	68.7	14	9	36
14	Average	15.3	<20	94.5	14.8	<20	21.1	12	<5	25
	Maximum	19.0	<20	112.3	20.9	32.2	58.6	16	<5	47
31	Average	NS	NS	NS	NS	NS	NS	11	<5	27
	Maximum	NS	NS	NS	NS	NS	NS	18	<5	56
43	Average	NS	NS	NS	24.6	<20	32.9	19	<5	23
	Maximum	NS	NS	NS	39.1	53.4	72.3	26	5	31
45	Average	NS	NS	NS	17.7	<20	32.5	13	<5	29
	Maximum	NS	NS	NS	30.7	47.9	76.9	17	6	49
46	Average	NS	NS	NS	17.1	<20	34.5	13	<5	25
	Maximum	NS	NS	NS	27.7	40.3	79.2	23	8	62
47	Average	NS	NS	NS	15.1	<20	50	14	<5	26
	Maximum	NS	NS	NS	18.8	<20	115.8	19	10	56
48	Average	NS	NS	NS	9.3	<20	19.8	6	<5	22
	Maximum	NS	NS	NS	13.0	32.8	43.9	11	14	38
49	Average	NS	NS	NS	4.4	<20	27.5	14	<5	27
	Maximum	NS	NS	NS	19.0	<20	51.6	29	6	52
50	Average	NS	NS	NS	6.9	<20	30.5	14	<5	26
	Maximum	NS	NS	NS	19.0	<20	68.6	29	<5	65
51	Average	NS	NS	NS	5.3	<20	28.8	22	<5	18
	Maximum	NS	NS	NS	19.3	<20	53.6	50	7	42
68	Average	NS	NS	NS	NS	NS	NS	12	<5	21
	Maximum	NS	NS	NS	NS	NS	NS	20	7	35
Statewide: [a]										
	Average	14.3	<20	51.3	9.9	<20	29.6	7.6	<5	< 20
	Maximum	30.0	59.2	165.3	30.0	49.0	118.0	31.0	10.0	60

[a] Excludes samples from NFS area.
NS, no sample.

that the decrease in the NFS area was not as great as the decrease in background in other areas of the State. The differences were extremely small and could not be directly related to stack releases. This phase of the study is being continued through 1969 and will be reported at a later date.

The data obtained through 1967 indicate that the stack discharges have not produced effects on the environment that might represent a public health hazard. The State Health Department, in cooperation with the U.S. Public Health Service, has been attempting to develop an economical means of monitoring for krypton-85 and other gaseous beta-particle emitters. Monitoring was not conducted during the 1965-1967 period to ascertain the presence of krypton-85 outside the fence line.

Effects of liquid waste discharges

A summary of liquid waste discharges reported by the company (*5*) is given in table 4. To a certain extent, the wastes were released in proportion to the flow in Cattaraugus Creek. Examination of tables 5, 6, and 7, and figure 4 indicate some general characteristics.

1. Higher concentrations of strontium-90 were found in Cattaraugus Creek in the fall and winter of 1966–1967 than were found in the latter part of 1967. Strontium-90 represents a significant part of the total gross beta radioactivity.

2. Cesium is removed in greater quantities in silt than strontium; most of the strontium-90 is found in the dissolved state.

3. The ratio of cesium-137 to cesium-134 in the wastes is about 4 or 5 to 1. Cesium-134 is indicative of spent fuel and is not a significant component of fallout from weapons testing.

Data on samples taken from the discharge of waste lagoon 3 are given in table 5.

The average and maximum values for radioactivity found in Buttermilk and Cattaraugus Creeks are summarized in table 6. Figures 3 and 4 show the average monthly concentrations of gross beta radioactivity and of strontium-90, respectively, in Cattaraugus Creek at Springville Dam (site 42 on figure 2). This is a State operated, continuous-sampling site, 2 miles downstream from Buttermilk Creek. The results show that the maximum limit allowed for strontium-90 by the AEC (300 pCi/liter) was not exceeded.

Values for silt samples are shown in table 7. A study of silt behind Springville Dam was made in June 1967. As might be expected, the larger particles near the inflow to the pond contained less radioactivity per unit weight than the smaller particles in the center of the pond.

Table 4. NFS monthly liquid waste discharge

Month	Volume (gallon)[a]	Total radioactivity released[b]		
		Alpha radioactivity (Ci)	Beta radioactivity (Ci)	Tritium (Ci)
1966				
February	200,000	6.3×10^{-4}	3.7×10^{-3}	0.73
March	1,200,000	1.6×10^{-4}	7.2×10^{-3}	2.46
April	587,000	1.8×10^{-3}	2.5×10^{-2}	.12
May	4,452,500	5.0×10^{-3}	9.0×10^{-2}	12.6
June	1,813,000	8.3×10^{-4}	2.0×10^{-1}	6.8
July	4,200,000	1.6×10^{-4}	1.4×10^{-1}	8.0
August	1,950,000	7.4×10^{-5}	2.2×10^{-1}	44.0
September	4,230,000	5.6×10^{-3}	2.5	160.0
October	2,934,000	2.9×10^{-3}	2.6	20.0
November	2,500,000	1.8×10^{-3}	1.1	13.0
December	3,061,000	1.5×10^{-2}	1.4	25.0
1967				
January	3,620,000	1.1×10^{-2}	4.1	300
February	4,000,000	4.0×10^{-3}	2.3	500
March	2,530,000	7.4×10^{-3}	1.5	280
April	1,650,000	2.3×10^{-3}	0.6	94
May	2,400,000	8.4×10^{-3}	1.7	500
June	2,000,000	1.6×10^{-3}	1.3	620
July	3,800,000	2.5×10^{-4}	1.5	650
August	2,400,000	0	1.4	270
September	2,700,000	2.9×10^{-3}	1.3	460
October	3,220,000	1.5×10^{-3}	2.4	340
November	2,770,000	1.3×10^{-3}	5.4	26
December	2,980,000	1.3×10^{-2}	7.2	160

[a] Calculated by NFS as 1,240,000 gallons per month in original safety analysis report.
[b] Limit 48 curies per quarter exclusive of tritium.

Table 5. Radioactivity in water samples from waste lagoon

Radioactivity (pCi/liter)[a]	Grab sample collected 1/29/67	Composite samples collected 6/67	Grab sample collected 7/67	Grab sample collected 9/8/67
Gross beta radioactivity				
Suspended	72,000	20,680	2,503	NA
Dissolved	248,000	230,400	93,233	NA
Strontium-90				
Suspended		203	69	
Dissolved	68,000	69,800	14,400	[b]4,050
Tritium	45,000,000	NA	NA	[b]91,000,000
Uranium (ppm by weight)	19.3	NA	NA	NA
Cobalt-60	2,000	NA	[b]360	[b]2,700
Ruthenium-106	227,000	NA	[b]43,000	[b]330,000
Cesium-134				
Suspended		NA	[b] 150	
Dissolved	15,000	NA	[b]1,100	[b]24,000
Cesium-137				
Suspended		NA	[b] 580	
Dissolved	63,000	NA	[b]5,700	[b]81,000
Iodine-129	NA	750	NA	NA
		Grab sample 6/14/67		
Antimony-125	NA	NA	[b]8,700	[b]39,000

[a] All concentrations are in units of pCi/liter except for uranium which is in units of ppm.
[b] Data from U.S. Public Health Service.
NA, no analysis.

A limited number of samples were examined to determine the presence of plutonium and uranium in the effluent and in local streams. The results, summarized in table 8, indicate that these radionuclides were not present in sufficient amounts to cause concern; however, they should be determined periodically in the future because of the variability of waste discharges.

Deer and fish sampling results are given in tables 9 and 10. The 3,300-acre site is surrounded by a 3-foot-high fence, and a 10-foot-high exclusion fence surrounds an area of 90 acres around the main part of the plant and burial site. Deer taken in 1966 were from the general NFS area outside the site perimeter fence. The deer samples taken inside the exclusion fence in December 1967

Table 6. Radioactivity in water samples

Site number and location	Concentration (pCi/liter)							
	1965		1966		1967			
	^{90}Sr	Gross beta	^{90}Sr	Gross beta	^{90}Sr	^{137}Cs	Gross beta	Tritium
4 Buttermilk Creek, upstream								
Average	<3		<3	2	<3	<20	6	1,570
Maximum	<3		<3	3	<3	<20	13	2,900
7 Cattaraugus Creek, upstream								
Average	<3		<3	2.5	<3	<20	5	1,860
Maximum	<3		<3	3	8	50	10	4,500
35 Buttermilk Creek, downstream								
Average	<3		[a] <3	[a]5.8	335	112	970	320,430
Maximum	<3		<3	15	1,305	506	4,668	1,452,000
42 Cattaraugus Creek, downstream								
Average	<3		62	116	24	<20	95	30,730
Maximum	<3		265	1,387	53	77	315	183,170
60 Cattaraugus Creek, downstream (Gowanda)								
Average	<3						52	21,510
Maximum	<3						157	100,950
65 Cattaraugus Creek, downstream (Irving Bridge)								
Average	<3						51	24,710
Maximum	<3						112	82,670
Statewide								
Average	<3	[b]11.7	[b] <3	[b]5.3	<3	<20	6	2,280
Maximum	9	[b]30	[b]5.6	[b]34	<3	<20	103	7,200

[a] Samples from Buttermilk Creek were not taken during period of discharge from Nuclear Fuel Services for latter half of year 1966.
[b] Fresh water samples excluding those collected from the Nuclear Fuels Services area.

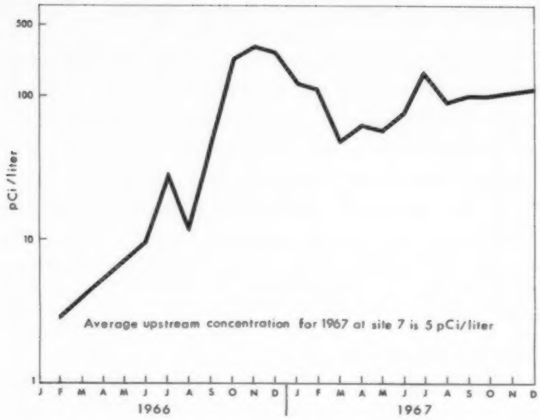

Figure 3. Gross beta concentrations at Springville dam site 42 - monthly averages, 1966–1967

are significantly higher in radioactivity, probably as a result of drinking contaminated water. There were two or three openings in the exclusion fence caused by stream erosion and deer had access to 2-½ miles of contaminated water in Buttermilk, Erdman, and Franks Creeks not protected by the exclusion fence.

The results of fish sampling reflect the three characteristics of wastes cited previously. The strontium-90 concentrations were high. Whole, uncleaned fish were analyzed; no attempt was made to analyze the flesh, bone, scales, and intestines separately. Most of the fish, obtained by shocking, were suckers, which are bottom feeders. Studies performed in the Clinch River (7) where similar wastes were discharged, showed that bottom feeders could have more strontium-90 than cesium-137 in the flesh. This relationship is unlike that in game fish, where the cesium-137 in flesh was higher. Suckers are taken from Cattaraugus Creek for food, especially in the springtime. In addition, there may be a practice of grinding up the flesh and bone to make fishburgers.

Table 7. Radioactivity in silt samples

Site number and location	Collection date	Concentration (pCi/g dry weight)					
		^{90}Sr	^{137}Cs	^{106}Ru	^{134}Cs	^{95}Zr–Nb	^{60}Co
35 Buttermilk Creek, downstream	8/29/66		74	47		88	6.3
	11/30/66	81	179	589		222	9.2
	2/27/67	3.9					
	3/ 6/67	4.8					
	3/20/67	.4					
	3/27/67	1.4					
4 Buttermilk Creek, upstream	11/30/66	.3	.2	1.7		.2	.1
	2/27/67	.1					
	3/ 6/67	.1					
	3/13/67	.2					
	3/20/67	< .01					
	3/27/67	< .01					
42 Cattaraugus Creek, downstream (Springville dam)	11/30/66	3.8	9	32		10.7	.4
	1/27/67		4.3	4.5	1.5	.8	.3
	2/28/67	1.2					
	3/ 7/67	9.9					
	3/14/67	.9					
Location A[a]	6/ 5/67[b]	.3	8.1	1.9	1.4		.2
B[a]	6/ 5/67[b]	.6	4.5	1.3	.8		.2
C[a]	6/ 5/67[b]	1.9	37.3	2.6	7.1		.4
D[a]	6/ 5/67[b]	2.5	44.4	2.8	5.2		.4
E[a]	6/ 5/67[b]	1.8	43.3	3.4	7.6		.5
F[a]	6/ 5/67[b]	1.2	19.4	3.5	3.5		.4
32 Cattaraugus Creek, downstream (Felton bridge)	9/28/66		6.5	22		6.7	.6
	11/30/66	4.6	8.3	28.3		9.5	.5
	3/ 7/67	.1					
	3/14/67	.6					
7 Cattaraugus Creek, upstream (Bigelow bridge)	9/28/66		.3	1.9		.2	.1
	11/30/66	1.6	< .1	< .9		< .1	< .1
	3/ 7/67	.6					
	3/14/67	.1					
	3/21/67	< .01					
	6/13/67[b]		.06				
5-mile Creek, south	1/27/67		.4	2.5		.4	
Cattaraugus County (background):							
61 Buttermilk Creek upstream, Pfeffer's Pond (background)	8/29/66		.7	7		.9	.6
52 Waste lagoon #3	1/29/67		11,100	18,700		11,100	1,700
	9/ 8/67[c]	770	11,100	2,900	2,400		74

[a] Locations A–E were taken through the center of the pond perpendicular to the dam; A was located at the upper end of the pond approximately 2,500 feet from the face of the dam; B, approximately 2,000 feet from the face of the dam; C, approximately 1,500 feet; D, approximately 1,000 feet; and E, approximately 500 feet. Location F was near the entrance to the penstock, abou' 60 feet from the face of the dam and 5 feet from the north shore.
[b] Data on gamma-ray emitters from the U.S. Public Health Service.
[c] Data from U.S. Public Health Service.

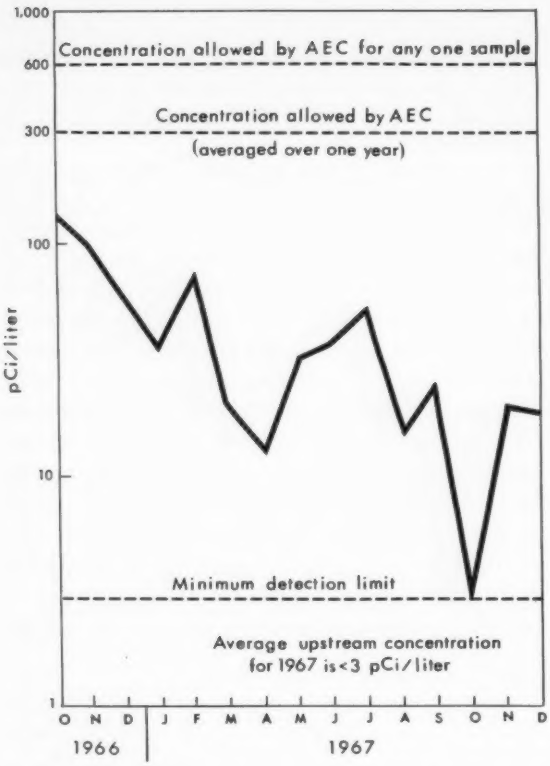

Figure 4. Strontium-90 concentrations in Cattaraugus Creek at Springville dam site 42

Significance of radioactivity in deer and fish

The levels of radioactivity in deer and fish were of sufficient magnitude to require careful evaluation of public health significance. In ascertaining this significance, the recommendations of the Federal Radiation Council (FRC) were used. The FRC has set forth Radiation Protection Guides (RPG) (*8*) for normal peacetime uses of atomic energy. For both whole body and bone marrow, the RPG for individuals is 0.5 rem/year, and the RPG for the average of a suitable sample of the exposed population group is 0.17 rem/year.

Calculations of the amount of deer meat or fish that could be consumed within the RPG limits were based on the following assumptions, which are considered to be conservative in terms of public health.

1. The highest levels of radioactivity found in fish and deer meat were used.
2. The RPG for an individual was used because it is unlikely that a large number of people would eat deer meat or fish, each having the highest level of radioactivity.
3. FRC Report No. 7 (*9*) was used as a reference to calculate exposure from ingestion of cesium-137. In this report, the dose to the whole body for an

Table 8. Plutonium and uranium in water and silt samples

Site number and location	Date	Concentration in water[a] (pCi/liter)				
		^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
42 Cattaraugus Creek at Springville Dam, downstream	10/25/66	0.023	<0.01	0.26	<0.002	0.19
	11/ 1/66	.063	< .02	.23	< .005	.41
	11/22/66	< .02	< .02	.44	< .12	< .01
	11/29/66	< .03	< .01	.18	< .06	.17
	1/ 3/67	< .5	< .5	.15	.11	.09
	1/10/67	1.16	.7	.15	< .02	.15
	[b]6/13/67	ND	ND	NA	NA	NA
7 Cattaraugus Creek at Bigelow Bridge, upstream	10/25/66	< .02	< .01	.10	< .01	.12
	11/ 1/66	.06	< .03	.16	< .007	.07
	11/22/66	< .03	.01	.16	< .008	< .01
	11/29/66	< .02	< .02	< .33	< .15	< .01
	[b]6/13/67	ND	ND	NA	NA	NA
52 Waste lagoon #3	[b]9/ 8/67	16	32	242	NA	112
		Concentration in silt (pCi/g)				
52 Waste lagoon #3	[b]1/29/67	39.3 (total plutonium)		ND (total uranium)		
	[b]9/ 8/67	3.1	4.7	8.8	NA	8.8
42 Cattaraugus Creek, Springville Dam	[b]6/13/67	ND	.03	.63	NA	.69

[a] Less than values are minimum detectables levels for State samples. Minimum detectables levels are determined by the amount of solids in the sample.
[b] Data by U.S. Public Health Service.
NA, no analysis.
ND, nondetectable.

Table 9. Radionuclides in soft tissues of deer

Sample number	Place taken	Date	Sample organs	Cesium-137 (pCi/kg)	Cesium-134 (pCi/kg)	Tritium (pCi/kg)
66-1	Otto	9/66	Stomach	150		
			Lungs	50		
66-2	Ashford		Stomach	100		
			Liver	100		
			Lungs	80		
66-3	E. Otto		Stomach	70		
			Lungs	150		
66-4	Mansfield		Stomach	160		
			Liver	140		
67-1	Within NFS plant	1/23/67	Lungs	490	120	
67-2	perimeter			195	40	
67-1		1/23/67	Heart	560	130	
67-2				200	<40	
67-3				490	95	
67-1		1/23/67	Liver	210	65	
67-2				150	40	
67-3				<30	<30	
67-4				135	20	
67-1		1/23/67	Stomach	480		
67-2				300		
67-3				370		
67-B	Within NFS exclusion fence	12/13/67	G.I. tract	17,382	3,130	
			Lungs	19,249	3,592	
			Liver	26,797	4,438	
			Meat	66,956	11,276	41,800
67-C		12/13/67	G.I. tract	5,560	1,010	
			Lungs	17,567	2,829	
			Liver	14,796	2,590	
			Meat	64,449	12,313	29,800
67-D		12/13/67	Lungs	19,438	3,140	
			Liver	24,251	3,856	
			Meat	33,135	5,651	46,300
67-E	Limestone (background)	1/29/68	Lungs	92	0	
			Meat	261	0	1,580

Table 10. Radioactivity in sample of whole fish

Site Number	Location	Collection date	Concentration (pCi/kg raw weight)					
			^{106}Ru	^{134}Cs	^{60}Co	^{137}Cs	^{40}K	^{90}Sr
4	Buttermilk Creek, upstream (Fox Valley Road)	[a]6/13/67	6.7	6.6		54	2,470	106
		[b]6/13/67						[b]2,640
		10/27/66						153
		10/27/65		16		79		
		6/22/65				5		
		10/ 7/64				58		
		6/30/64				<32		
35	Buttermilk Creek, downstream (Thomas Corners Road)	[a]6/13/67	1,730	5,750	340	27,500	5,190	15,300
		[b]6/13/67						[b]3,200
		10/27/66						81
		10/27/65		870	277	1,685		
		6/22/65				33		
7	Cattaraugus Creek, upstream (Bigelow Bridge)	[a]6/13/67	88	190	19	871	2,690	875
		[b]6/13/67						[b]34
		10/27/66						12,350
		10/27/65				21		
		6/22/65				23		
32	Cattaraugus Creek, downstream (Felton Bridge)	[a]6/13/67	499	796	25	3,610	3,030	906
		[b]6/13/67						[b]137
		10/27/66						1,035
		10/27/65		244	46	455		
		6/22/65				19		
		10/ 7/64				<32		
		6/30/64				<64		
62	Cattaraugus Creek, downstream (Frye Bridge)	[a]6/13/67	289	348	32	1,570	3,170	564

[a] Data for this collection date by U.S. Public Health Service.
[b] Samples received in decomposed state and were ashed without obtaining raw weight. A ratio of 1.5 percent ash weight was used to convert from ashed weight to raw weight on basis of similar fish samples.

adult weighing 70 kg, from the ingestion of 1 microcurie of cesium-137, was estimated as 0.06 rad. The dose from ingestion of cesium-134 was determined by multiplying the dose per microcurie of cesium-137 by a factor of 1.87, the ratio of energy release per disintegration of cesium-134 compared to cesium-137.

4. FRC Report No. 2 (*8*) indicates that the ingestion of 200 pCi of strontium-90 per day per gram of dietary calcium generally corresponds to one-third of the appropriate RPG averaged for an exposed population group; therefore, since the daily calcium intake is about 1 g per day, the exposure to bone marrow is based on the assumption that ingestion of 600 picocuries of strontium-90 per day results in a dose of 0.17 rad/year.

5. Exposure from the ingestion of tritium was calculated from recommedations of the National Council on Radiation Protection and Measurement (NCRP) and was used to illustrate the principle of considering total exposure from all radionuclides present. Although the exposure from tritium was extremely small, all possible sources must be considered in the accumulated exposure.

6. The critical organ for strontium-90 ingestion is bone marrow; for cesium-137, cesium-134, and tritium, it is the whole body. In determining allowable consumption of fish based on bone marrow, the concentrations from the two cesium isotopes were conservatively added, based on whole body exposure.

7. No analysis was made for strontium-90 in deer meat, but it could contribute additional exposure to the bone marrow of a person eating both deer meat and fish.

8. The fish data represent measurements for unscaled and ungutted samples. A conservative assumption was made that the concentration of strontium-90 in the edible parts of the fish was the same as for the entire fish. In the future, separate analysis of the edible portion of the fish will be made to provide information on how conservative this assumption was.

The calculations for allowable consumption of deer meat and fish are in table 11.

If fish were the only source of exposure, the amount of fish that could be consumed without exceeding the RPG was calculated as 78 pounds per year. The amount of deer meat that could be consumed, if this were the only source of exposure, was calculated as 220 pounds per year. Deer within the exclusion area are not readily accessible to hunters and the possiblity of many deer being scared out of the exclusion area and the site seems remote. The fish appear to reconcentrate the radioactivity, have ready access to the streams, and represent the more critical pathway for human exposure.

Table 11. The calculations for allowable consumption of deer meat and fish

Nuclide	Concentration (μCi/kg)	Exposure (rads/μCi)	Dose (rad/kg)
Deer meat[a]			
Cesium-137	0.067	0.06	0.00402
Cesium-134	.011	.11	.00121
Tritium	.040	.0002	.000008
Total			0.00524
Fish (suckers)[b]			
Strontium-90	0.0153	.78	0.0120
Cesium-137	.0275	.06	.0016
Cesium-134	.005	.11	.0006
Total			0.0142

[a] Allowable consumption of deer meat for an adult (based on whole body exposure). $= \frac{0.5 \text{ rad/yr}}{.005 \text{ rad/kg}}$ = 100 kg/yr = 220 pounds/yr.

[b] Allowable consumption of fish for an adult (based on bone marrow exposure). $= \frac{0.5 \text{ rad/yr}}{.014 \text{ rad/kg}}$ = 35.7 kg/yr = 78 pounds/yr.

If additional consideration is given to the possibility that the plant may eventually discharge up to the limits allowed, and if exposures to an individual from other sources such as krypton-85 are added to the total accumultated exposure, there is a possibility that the RPG may be exceeded. In order to assure that the RPG will not be exceeded and to reduce the risk to health, certain actions have been taken.

Discussion

The New York State Health Department has taken actions which are in conformance with recommendations of the Federal Radiation Council. In December of 1966, the unexpected concentrations of strontium-90 in Cattaraugus Creek were brought to the attention of NFS and the AEC. The data indicate that the company has made an effort to reduce the amount of strontium-90 in the streams. The Health Department also started to place more emphasis on stream surveillance.

As the data on fish and deer became available, the possibility of these being the most critical pathways was established. Further sampling studies were planned in accordance with the FRC recommendation that additional sampling be conducted when it appears that the RPG may be exceeded. The company was asked to repair holes in the fence of the exclusion area to exclude deer from the waste storage lagoons.

The Department used the RPG as a measure of the public health significance and calculations indicated that an immediate public health hazard did not exist. However, the FRC philosophy that "every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable" (*8*) was considered and applied. The Health Department's concern over the levels of radioactivity in the liquid waste discharge has been discussed with representatives of the AEC which has required NFS to make significant reductions in the levels of radioactivity discharged to the watershed. The Health Department has increased the surveillance program around the NFS plant and will continue to evaluate the release of radioactivity to the environment.

Acknowledgement

The author would like to acknowledge the valuable advice and analytical services provided by the PHS Northeastern Radiological Health Laboratory, Winchester, Mass., particularly for the data in tables 5 through 11 where sample analysis was performed by them. Also acknowledged is the excellent analytical laboratory work performed by the Radiological Sciences Group of the New York State Health Department's Division of Laboratories and Research.

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A 5-Year Summary of the Regulatory Control of Radioactive Material in Arkansas

E. F. Wilson and D. D. Snellings, Jr.[1]

On July 1, 1963, the State of Arkansas entered into an agreement with the U.S. Atomic Energy Commission (AEC) establishing the Arkansas Radiological Health program. The agreement transferred regulatory control of all radioactive material, including fissionable material of less than critical mass quantity, from the Atomic Energy Commission to the State of Arkansas. The Arkansas State Department of Health, Division of Radiological Health, was designated as the responsible agency by Act 8 of the Second Extraordinary Session of the Arkansas Legislature in 1961. In addition to assuming the control of previously regulated material, the Division of Radiological Health now controls all sources of ionizing radiation (i.e., radiation machines and radium). It should be noted that prior to 1963 the use of radium had never been regulated and several instances of improper management and usage were reported on initial compliance inspections.

In assuming the regulatory control of radioactive material, the Arkansas State Department of Health, Division of Radiological Health, instituted a program of licensing and inspection of all users of regulated material with the ultimate goal of preventing, if possible, or reducing to an acceptable level, the exposure to ionizing radiation.

This report is a summary of regulatory activities of the Division of Radiological Health from 1964 through and including 1968. The early (1964) regulatory inspections did not include sufficient data pertaining to the occupational exposure of individuals to radiation; however, the noted deficiencies of records and radiation safety are well documented. In early 1967, the Division of Radiological Health prepared all previous data for electronic data processing, and currently all regulatory inspections, as well as licensing activities, are prepared for electronic data processing[2] on a routine basis.

Upon receipt of an application for a radioactive material license, a systematic evaluation of the applicant's qualifications, equipment, and facilities, is initiated to insure, if the license is granted, capability for compliance with the current standards of radiation protection. The evaluation is designed to detect and eliminate any deficiency that might result in an unnecessary exposure to both the licensee and general public. Licensing guides which are compatible with those used by the U.S. Atomic Energy Commission (AEC) aid in the evaluation of a license application. An onsite prelicensing visit is made if deemed necessary by the complexity of an application.

The Division of Radiological Health initiated licensing activities in July 1963 through the issuance of Arkansas licenses for radioactive material not previously regulated. Until 1965, AEC licenses were continued as valid Arkansas licenses until their individual expiration dates, at which time they were reissued as Arkansas licenses. Table 1 shows the total number of active licenses by year and type of installation.

Examination of the data reveals a marked increase in the number of medical institution licenses, which may be attributed to the licensing of radium and the expiration of AEC licenses. In 1964, a survey was initiated to locate all radium users within the State and subsequently 22 licenses were issued. Presently, there are 32 licenses issued for radium use. The increase in the number of State and Federal laboratory licenses in 1965 is due to the licensing of civil defense personnel who routinely use radioactive material

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[2] The data reduction and resulting statistical summary of this report were processed on an IBM System 360/20 computer.

Table 1. Compilation of licenses by year, 1963–1968

Year	Medical		College and University		Industrial firms		Federal and State lab		Other		Civil Defense user permit[a]		Total
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
1963	27	28.12	5	5.20	27	28.12	6	6.25	31	32.29	0	0	96
1964	23	41.07	5	8.92	20	35.71	6	10.71	2	3.57	0	0	56
1965	48	27.58	16	9.19	18	10.34	92	52.87	0	0	0	0	174
1966	53	23.76	17	7.62	28	12.55	125	56.05	0	0	0	0	223
1967	50	18.58	17	6.31	44	16.35	158	58.73	0	0	0	0	269
1968	55	29.96	16	7.84	57	27.94	12	5.88	0	0	64	31.37	204

[a] Initiated November 1968.

for instructional purposes in radiological monitoring instructors courses conducted throughout the State. As reflected in table 1, a program was initiated in November 1968 to issue "user-permits" to qualified civil defense personnal under a specific license currently held by the State Radiological Defense officer. These civil defense user permits are included in table 1 because they are reported to AEC as individual licenses.

Upon receipt of a license to use radioactive material, the licensee is required to comply with the "Rules and Regulations for the Control of Sources of Ionizing Radiation" and any special conditions set forth in the license. Compliance inspections are conducted at each licensee facility according to a priority system that is not based on user categories, but on the following parameters.

1. Type, composition and quantity of radioactive materal;
2. Location and use of radioactive material;
3. Particular health hazards involved with the radioactive material;
4. Established leak test intervals for radioactive sources.

The inspection priority system ranges from one inspection semiannually to one inspection within a 3-year period, depending on the particular license; each licensee is inspected at least once every 3 years.

Compliance inspections are performed by health physicists, who have received intensive training in the regulation and control of radioactive material, and each inspection is completely documented for further reference and action. If an item of noncompliance is found, the licensee acknowledges the deficiency and corrective action is required within 30 days. Followup inspections are conducted to review the corrective action of all major items of noncompliance.

During the 5-year period (1964–1968), 247 compliance inspections were conducted, as shown in table 2 by broad categories of licenses.

Table 2. Inspection and enforcement data, 1964–1968

	Medical	Educational	Industrial Radiography	Industrial	Other	Total
Total number inspections	147	43	9	40	8	247
Form report—no answer required; deficiencies noted	142	41	9	40	8	240
Formal written notification of noncompliance—answer required	5	2	0	0	0	7
Number licenses in compliance at time of inspection	55	29	4	21	5	114
Percent licenses in compliance	37.4	67.4	44.4	52.5	62.5	46.2

Table 3 shows the total number of active licenses and the number of inspections conducted during a particular year. The discrepancy between the total number of licenses issued and the total number of inspections conducted is attributed to the presence of civil defense licensees, who are

Table 3. Number of licenses and inspections by year

Year	Total number of licenses	Total number of inspections
1964	96	21
1965	174	53
1966	223	49
1967	269	59
1968	204	65

not routinely inspected, as well as a large number of out-of-state licensees who enter the State on a very limited basis. Medical licensees, both private practice and medical institutions, comprise approximately 59.9 percent of the total number of inspections. This large percentage results from the fact that all medical licenses, with the exception of three, are inspected annually, while the majority of the other catagories are inspected less often because they are of a less critical priority, or are out-of-state licenses, or are not actively engaged in operations involving radioactive material. The enforcement data also show that only about 2.84 percent of the compliance inspections required formal written notification of any major item of noncompliance noted during the inspection. The other 97.16 percent required only a form report which was completed at the time of the inspection. At the time of the inspection only 37.4 percent of the medical category were found to be in compliance with the regulations as opposed to 67.4 percent of the educational category that were in compliance. These results were to be somewhat expected because the medical licenses included a greater inventory of radioactive material and greater use factor. Although all industrial firms licensed to use radioactive material in the State are included in the overall statistics, many are actually out-of-state firms that enter only on a limited basis and this results in a limited number of inspections conducted on industrial radiography installations.

A compilation of the number of noncompliance items by license category is shown in table 4. All license categories average less than one violation per license over a 5-year period. The total number of violations incurred during the inclusive period was found to be 143.

Table 4. Number of noncompliance items by license category, 1964–1968

License category	Number of inspections	Number of licenses with: 1–3 violations	4–6 violations	7–9 violations	>9 violations	Average violations per license
Medical	147	67	2	1	0	0.75
Educational	43	6	0	0	0	.18
Industrial	40	10	0	0	0	.35
Industrial radiography	9	2	0	0	0	.44
Other	8	1	0	0	0	.12
Total	247	86	2	1	0	.57

The deficiencies noted on compliance inspections are categorically divided according to the Atomic Energy Commission's "Agreement States Inspection and Enforcement Data" listing. Additional information about the deficiency is accumulated by subdividing the deficiency into a more detailed listing. For the purpose of this report only the AEC listing will be used.

As noted previously, a total of 143 deficiencies were found during the 5-year period. Frequency distribution tables have been prepared by type of deficiency and general license category. The deficiencies have been further divided into the following classificatons:

a. Administrative
b. Radiation safety
c. Personnel monitoring
d. Posting
e. Other

The total number of administrative-type deficiencies, shown in table 5, was found to be 37. Within this group it was found that medical licensees were deficient in all but one category and accounted for approximately 68 percent of the total number of deficiencies. The most widely found deficiences were the (1) improper record keeping of disposals and leak testing; and (2) possession of radioactive material not authorized by the license. Overall, the most frequently occurring deficiency of all license categories was the improper recording of leak test results, with the medical licensees incurring six of the deficiencies. Since this report has cited the medical licensees as accounting for the largest number of deficiencies, it should be noted that most hospitals and radiology groups possess a greater number of radioactive sources requiring periodic leak testing than do other licensees.

The deficiencies noted in the radiation safety category, as shown in table 6, accounted for 59 percent of the total number of deficiencies. During the 5-year period, 60 deficiencies involving the leak testing of sealed sources were discovered with the medical licensees accounting for approximately 87 percent of the deficiencies. The most probable reason or cause of the deficiency is the failure to perform the test; only in a few isolated cases were the tests performed in an unacceptable manner. The majority of the leak testing deficiencies occurred in medical installations that are licensed

Table 5. Administrative items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Improper records of leak testing	6	2	0	2	0	10
Records of surveys and disposal	6	1	0	0	0	7
Records of receipt and transfer	2	1	0	3	0	6
Possession of material without license	6	0	0	0	0	6
Regulations or operating procedures not available	2	0	0	2	0	4
Possession of unauthorized form or amount of material	2	0	0	0	0	2
Failure to report overexposures	1	0	0	0	0	1
Unauthorized use of material	0	0	0	1	0	1
Total	25	4	0	8	0	37

Table 6. Number of radiation safety items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Failure to leak test or improper leak test	52	3	0	4	1	60
Radiation survey not performed	11	0	0	0	0	11
Improper waste disposal procedures	5	0	0	0	0	5
Security of material in storage	1	0	0	0	0	1
Level of radiation in uncontrolled areas	0	0	0	1	0	1
Inventory not maintained or improper utilization logs	0	0	0	1	0	1
Total	70	3	0	5	1	79

to use radium-226. Because of the high frequency of leaking radium sources, the current leak test interval is on a 6-month basis, while the leak test interval on other types of sealed sources varies from 6 months to 3 years depending on the particular sealed source. Several times during the inclusive period, leaking radium sources were discovered during leak tests, the correction of which reduced contamination incidence. During the period, 1964–1968, several contamination incidents occurred which could possibly have been prevented if the leak tests had been performed as scheduled. Other incidents of failure to perform the leak test have occurred at educational institutions and industries; however, the frequency of these violations have been extremely low.

One serious incident occurred and was investigated by the Division of Radiological Health during the reported period. The incident involved the accidental dropping of a 194 curie cobalt-60 source during a source exchange operation. Prompt emergency actions by the individuals involved in the exchange resulted in the rapid evacuation of four floors of the multifloor office building and consequently no overexposures were recorded.

Table 7 shows those deficiencies dealing with personnel monitoring, posting, and unclassified deficiencies. These account for approximately 18.9 percent of the 143 total deficiencies shown on table 5. In general, the deficiencies noted are quite low considering the number of licensees and occupationally exposed personnel. The most frequently occurring deficiency during this period was the absence of caution signs and labels. The extent of the personnel monitoring of occupationally exposed personnel is shown in the data in table 8, which was obtained on 65 compliance inspections conducted in 1968. Overall, 97.3

Table 7. Number of personnel monitoring, posting and unclassified items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Improper personnel monitoring system	1	1	0	0	0	2
Improper personnel monitoring records	5	0	0	0	0	5
Absence of control device or signal	1	0	0	0	0	1
Absence of caution signs and labels	8	0	0	0	0	8
Absence of notice to employees signs	1	0	0	1	0	2
Other deficiencies not categorized	7	0	0	0	2	9
Total	23	1	0	1	2	27

percent of the 480 occupationally exposed personnel of the 65 installations are monitored by either a film badge service or personnel dosimetry or both.

Table 8. Personnel monitoring of 65 installations inspected in 1968

License category	Number occupationally exposed	Number Monitored
Medical	398	394
Educational	65	61
Industrial radiography	6	6
Industrial	5	5
Other	6	0
Total	480	466

Summary

The State of Arkansas has regulated the use of radioactive material for a 5-year period from 1964 through 1968. Data resulting from licensing and inspection activities for that period have been presented and examined. The accumulation and presentation of this data indicate that several items of noncompliance are recurring and will require greater emphasis on future compliance inspections. Particularly noted was the need for timely leak testing of sealed sources and the maintenance of adequate records of the test. Medical licensees, while constituting the large majority of the total licensees, have additionally incurred the largest percentage of violations.

It is anticipated that the compliance percentage, both overall and categorical, will increase in the future as a result of the educational nature of the compliance inspection.

Data

SECTION I. MILK AND FOOD

Milk Surveillance, April 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

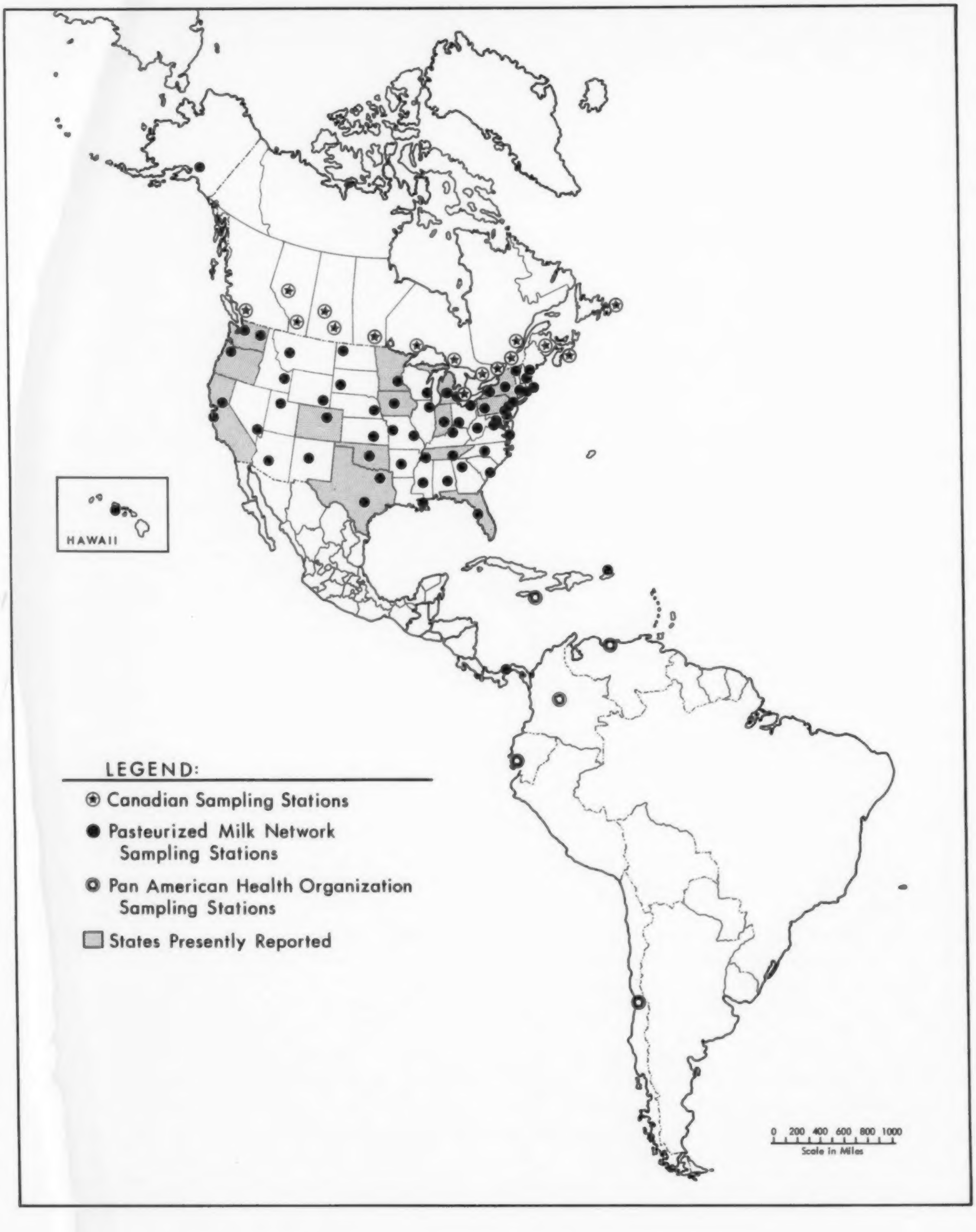

Figure 1. Milk sampling networks in the Western Hemisphere

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3- standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases of 20 to 30 percent from the expected values (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium–137 are relatively stable over time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a one or two year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which, if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr;	3 in first yr; total	[c]1,110,000
Strontium-90	Bone marrow	total dose not to	dose not to exceed	[c]51,000
Cesium-137	Whole body	exceed 15[a,b]	5[a,b]	[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segement of the population.

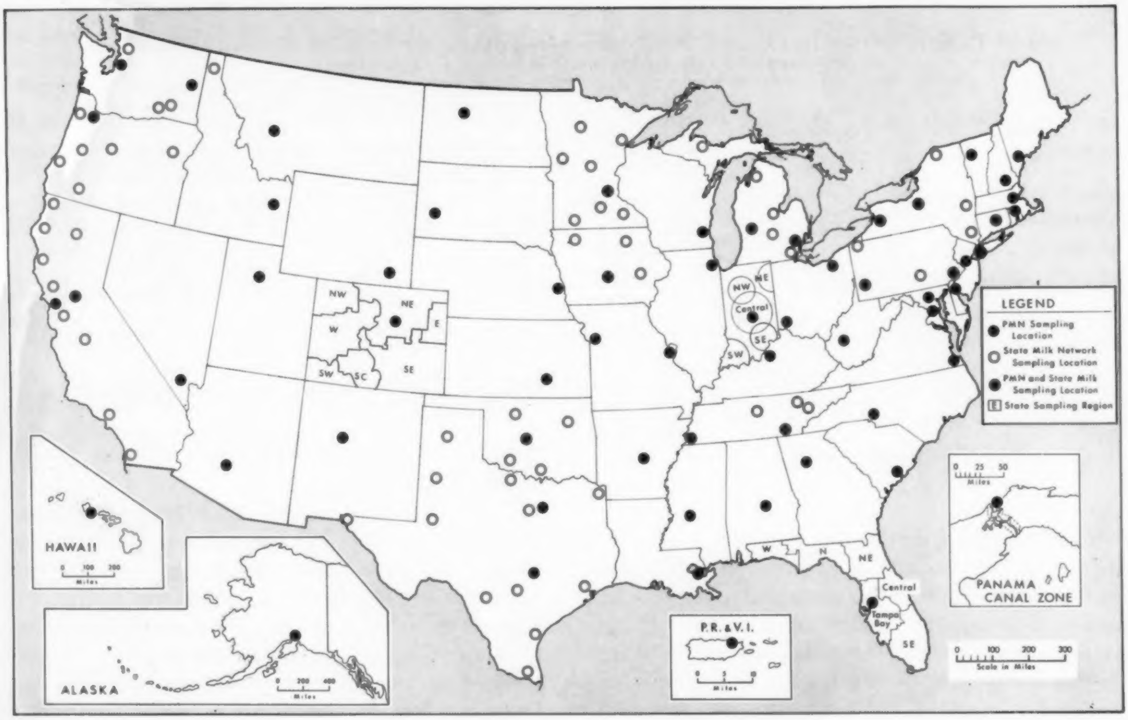

Figure 2. State and PMN milk sampling locations in the United States

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12–month average serves as a basis for comparison.

Discussion of current data

In table 3 surveillance results are given for strontium-90, iodine-131, and cesium-137 for April 1969 and the 12-month period, May 1968 to April 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for April 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 and barium-140 were detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	8	0 (4)	0	13 (4)	13
Alaska:	Palmer[c]	P	8	6	0 (2)	0	13 (2)	13
Ariz:	Phoenix[c]	P	2	0	0 (4)	0	0 (4)	1
Ark:	Little Rock[c]	P	22	21	0 (2)	0	16 (2)	19
Calif:	Sacramento[c]	P	3	1	0 (4)	0	0 (4)	2
	San Francisco[c]	P	5	1	0 (4)	0	3 (4)	3
	Del Norte	P	27	19	0	0	25	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	8	4	0	0	14	12
	Los Angeles	P	0	1	0	0	0	4
	Mendocino	P	7	2	0	0	11	3
	Sacramento	P	3	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	5	3	0	0	13	6
	Sonoma	P	6	2	0	0	0	4
Colo:	Denver[c]	P	4	4	0 (3)	0	0 (3)	4
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		NS	1	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		(e)	(e)	(e)	(e)
	South central	R	(d)		(e) (2)	(e)	(e)	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS		NS	
Conn:	Hartford[c]	P	8	9	0 (4)	0	15 (4)	12
	Central	P	6	8	0 (4)	0	8 (4)	10
Del:	Wilmington[c]	P	9	10	0 (5)	0	8 (5)	9
D.C.:	Washington[c]	P	9	9	0 (4)	0	0 (4)	6
Fla:	Tampa[c]	P	6	8	0 (4)	0	50 (4)	62
	West	R	11	12	0	3	24	26
	North	R	22	15	0	0	28	35
	Northeast	R	10	9	0	2	38	73
	Central	R	6	9	0	1	45	99
	Tampa Bay area	R	8	8	0	0	55	71
	Southeast	R	9	9	0	0	58	109
Ga:	Atlanta[c]	P	8	13	0 (4)	0	16 (4)	19
Hawaii:	Honolulu[c]	P	4	4	0 (4)	0	0 (4)	2
Idaho:	Idaho Falls[c]	P	5	6	0 (5)	0	9 (5)	9
Ill:	Chicago[c]	P	6	8	0 (4)	0	7 (4)	10
Ind:	Indianapolis[c]	P	8	8	0 (5)	0	0 (5)	6
	Northeast	P	7	11	0	0	0	12
	Southeast	P	4	10	0	0	5	12
	Central	P	9	9	0	0	10	10
	Southwest	P	7	9	0	0	10	10
	Northwest	P	8	9	0	0	10	12
Iowa:	Des Moines[c]	P	7	6	0 (4)	0	0 (4)	4
	Iowa City	P	10 (2)	7	0 (2)	0	10 (2)	8
	Des Moines	P	7 (5)	6	0 (4)	0	5 (5)	5
	Spencer	P	6	6	0	0	16	7
	Fredericksburg	P	10	10	0	0	0	0
Kans:	Wichita[c]	P	5	7	0 (4)	0	6 (4)	4
Ky:	Louisville[c]	P	9	12	0 (4)	0	5 (4)	7
La:	New Orleans[c]	P	17	19	0 (2)	0	23 (2)	21
Maine:	Portland[c]	P	10	12	0 (4)	1	20 (4)	26
Md:	Baltimore[c]	P	8	10	0 (4)	0	3 (4)	8
Mass:	Boston[c]	P	11	12	0 (5)	0	20 (5)	24
Mich:	Detroit[c]	P	8	9	0 (5)	0	10 (5)	11
	Grand Rapids[c]	P	9	11	0 (4)	0	14 (4)	15
	Bay City	P	NA	5	0 (2)	0	17 (2)	10
	Charlevoix	P	NA	7	0 (2)	0	19 (2)	12
	Detroit	P	5 (2)	5	0 (5)	0	8 (5)	5
	Grand Rapids	P	9	6	0 (4)	0	13 (4)	10
	Lansing	P	(b)	5	0 (2)	0	11 (2)	4
	Marquette	P	NA	9	0 (2)	0	27 (2)	28
	Monroe	P	NA	3	0 (2)	0	0	1
	South Haven	P	7 (2)	7	0 (4)	0	10 (4)	7
Minn:	Minneapolis[c]	P	8	11	0 (5)	0	10 (5)	14
	Bemidji	P	17	16	0	0	12	23
	Mankato	P	14	7	0	0	14	0
	Rochester	P	9	9	0	0	15	0
	Duluth	P	20	20	0	0	19	30
	Worthington	P	9	7	0	0	10	0
	Minneapolis	P	14	13	0	0	0	14
	Fergus Falls	P	11	10	0	0	10	11
	Little Falls	P	10	10	0	0	11	16
Miss:	Jackson[c]	P	11	15	0 (3)	0	20 (3)	16
Mo:	Kansas City[c]	P	9	7	0 (4)	0	0 (4)	3
	St. Louis[c]	P	7	9	0 (4)	0	5 (4)	5
Mont:	Helena[c]	P	6	4	0 (4)	0	3 (4)	8
Nebr:	Omaha[c]	P	7	6	0 (4)	0	3 (4)	4
Nev:	Las Vegas[c]	P	0	1	0 (5)	0	0 (5)	1

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H.:	Manchester[c]	P	7	12	0 (5)	0	18 (5)	33
N.J.:	Trenton[c]	P	9	9	0 (5)	0	8 (5)	11
N.Mex:	Albuquerque[c]	P	4	2	0 (4)	0	0 (4)	2
N.Y.:	Buffalo[c]	P	7	8	0 (4)	0	12 (4)	10
	New York City[c]	P	11	12	0 (4)	0	12 (4)	15
	Syracuse[c]	P	8	9	0 (5)	0	8 (5)	9
	Albany	P	4	8	0	0	0	0
	Buffalo	P	NA	0	NA	0	NA	0
	Massena	P	9	11	0 (2)	0	0 (2)	21
	Newburg	P	5	11	0 (4)	0	0 (4)	0
	New York City	P	5	12	0 (4)	0	0 (4)	0
	Syracuse	P	4	8	11 (2)	0	0 (2)	0
N.C.:	Charlotte[c]	P	14	15	0 (3)	0	9 (3)	11
N.Dak:	Minot[c]	P	12	11	0	0	8	13
Ohio:	Cincinnati[c]	P	8	9	0 (5)	0	0 (5)	5
	Cleveland[c]	P	8	9	0 (4)	0	6 (4)	8
Okla:	Oklahoma City[c]	P	9	9	0 (4)	0	8 (4)	7
	Oklahoma City		NS					
	Enid		NS					
	Tulsa		NS					
	Lawton		NS					
	Ardmore		NS					
Ore:	Portland[c]	P	9	7	0 (4)	0	8 (4)	12
	Baker	P	NA	3	(e)	(e)	23	8
	Coos Bay	P	NA	9	(e)	(e)	(e)	15
	Eugene	P	NA	4	(e)	(e)	17	12
	Medford	P	NA	3	(e)	(e)	23	14
	Portland composite	P	NA	5	(e)	(e)	14 (4)	8
	Portland local	P	NA	5	(e)	(e)	(e) (4)	7
	Redmond	P	NA	3	(e)	(e)	19	6
	Tillamook	R	NA	7	(e)	(e)	23	27
Pa:	Philadelphia[c]	P	8	10	0 (3)	0	5 (3)	8
	Pittsburgh[c]	P	12	12	0 (4)	0	11 (4)	11
	Dauphin	P	6	8	NA		12	18
	Erie	P	3	11	NA		23 (2)	21
	Philadelphia	P	NS	10	NS		NS	17
	Pittsburgh	P	7	11	NA		9	15
R.I.:	Providence[c]	P	7	10	0 (5)	0	18 (5)	19
S.C.:	Charleston[c]	P	10	13	0 (4)	0	23 (4)	24
S.Dak:	Rapid City[c]	P	5	9	0 (3)	0	4 (3)	9
Tenn:	Chattanooga[c]	P	11	13	0 (3)	0	11 (3)	13
	Memphis[c]	P	10	11	0 (4)	0	9 (4)	6
	Chattanooga	P	12	11	0 (4)	0	17 (4)	17
	Clinton	P	12	13	0 (3)	0	16 (3)	18
	Knoxville	P	8	9	0 (2)	1	7 (2)	11
	Nashville	P	7	9	6 (2)	0	6 (2)	9
Tex:	Austin[c]	P	3	3	0 (3)	0	3 (3)	2
	Dallas[c]	P	7	8	0 (3)	0	8 (3)	7
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	NS	4	NS	0	NS	2
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	11	6	0	0	10	8
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	9	9	0	0	20	19
	Lubbock	R	NS	10	NS	0	NS	2
	Midland	R	3	3	0	0	0	0
	San Antonio	R	NS	2	NS	0	NS	0
	Texarkana	R	NS	11	NS	0	NS	18
	Uvalde	R	2	2	0	0	0	0
	Wichita Falls	R	NS	9	NS	0	NS	2
Utah:	Salt Lake City[c]	P	5	5	0 (5)	0	11 (5)	11
Vt:	Burlington[c]	P	7	10	0 (4)	0	9 (4)	11
Va:	Norfolk[c]	P	11	11	0 (4)	0	11 (4)	10
Wash:	Seattle[c]	P	7	8	0 (4)	0	15 (4)	20
	Spokane[c]	P	8	7	0 (5)	0	4 (5)	8
	Benton County	R	NS	1	NS	0	NS	6
	Franklin County	R	3	1	0	0	0	0
	Sandpoint, Idaho	R	11	9	0	0	19	24
	Skagit County	R	10	5	0	0	0	12
W.Va:	Charleston[c]	P	8	12	0 (3)	0	9 (3)	8
Wisc:	Milwaukee[c]	P	7	7	0 (4)	0	14 (4)	12
Wyo:	Laramie[c]	P	5	5	0 (5)	0	5 (5)	11
CANADA:								
Alberta:	Calgary	P	5	8	(d)		16	18
	Edmonton	P	8	8	(d)		11	19
British Columbia:								
	Vancouver	P	10	13	(d)		31	45
Manitoba:	Winnipeg	P	8	8	(d)		17	24
New Brunswick:								
	Frederickton	P	10	15	(d)		11	21

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)							
Newfoundland:							
St. Johns	P	12	19	(d)		25	40
Nova Scotia: Halifax	P	9	11	(d)		12	21
Ontario: Ft. William	P	16	16	(d)		32	32
Ottawa	P	9	9	(d)		15	19
Sault Ste. Marie	P	16	15	(d)		24	34
Toronto	P	6	5	(d)		7	15
Windsor	P	6	6	(d)		6	14
Quebec: Montreal	P	8	9	(d)		15	20
Quebec	P	12	12	(d)		21	28
Saskatchewan:							
Regina	P	6	7	(d)		13	17
Saskatoon	P	5	9	(d)		12	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	NS	1	NS	0	NS	0
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Kingston	P	3	6	0	0	45	100
Venezuela Caracas	P	NA	1	0	0	0	0
Canal Zone: Cristobal[c]	P	0	2	0 (4)	1	6 (4)	13
Puerto Rico: San Juan[c]	P	4	5	0 (3)	0	8 (3)	7
PMN network average[f]		8	9	0	0	8	11

[a] P, pasteurized milk.
R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] Radionuclide analysis not routinely performed.
[e] The practical reporting levels for these networks differ from the general ones giving in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado–25 pCi/liter
Michigan–14 pCi/liter
Oregon–15 pCi/liter

Cesium-137: Colorado–25 pCi/liter
New York–20 pCi/liter
Oregon–15 pCi/liter
Washington–15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Table 4. Monthly average of strontium-89 and barium-140 in milk, April 1969

Sampling location	Radionuclide concentration (pCi/liter)	
	Strontium-89	Barium-140
Calif: Del Norte	19	
Santa Clara (State)		12
Shasta (State)		24
Idaho: Idaho Falls (PMN)		2(5)
Mo: Kansas City (PMN)		2(4)
Nebr: Omaha (PMN)		2(4)
Nev: Las Vegas (PMN)		3(5)
Tenn: Clinton (State)		4(3)

Strontium-90 monthly averages ranged from 0 to 27 pCi/liter in the United States for the month of April 1969 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.,) representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 58 pCi/liter in the United States for the month of April 1969 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level except Nashville, Tenn. (State) 6 pCi/liter, 2 samples.

Acknowledgment

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California State Department of Health

Radiological Health Section
Division of Air, Occupational, and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	November–December 1967 and January–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet Study, *PHS*	July–September 1968	April 1969
Tri-City Diet, *HASL*	January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	January–June 1968	April 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1966–June 1967	June 1969

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Gross Radioactivity in Surface Waters of the United States January 1969

Division of Pollution Surveillance
Federal WaterPollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

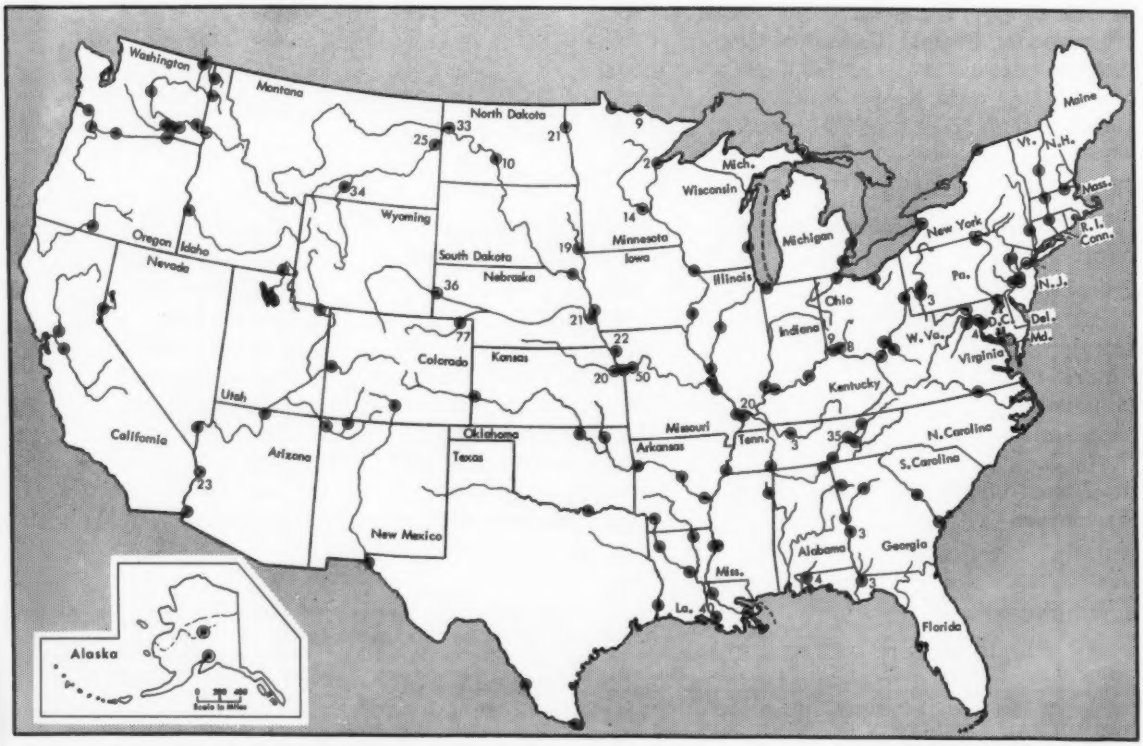

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, January 1969

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations in the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During January 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter for either suspended or dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

Also, during January 1969, no station showed beta radioactivity values in excess of 150 pCi/liter.

REFERENCES

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(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
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(*5*) *Ibid.*, 1962 Edition.
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(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, January 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Apalachicola River:						
Chattahoochee, Fla	0	0	0	1	2	3
Atchafalaya River:						
Morgan City, La	8	0	8	34	6	40
Big Horn River:						
Hardin, Mont	1	2	3	10	24	34
Big Sioux River:						
Sioux Falls, S. Dak	0	3	3	<1	19	19
Chattahoochee River:						
Columbus, Ga	0	0	0	1	2	3
Clinch River:						
Kingston, Tenn[a]	0	0	0	2	33	35
Colorado River:						
Parker Dam, Calif-Aris	0	6	6	1	22	23
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	3	3
Escambia River:						
Century, Fla	0	0	0	1	3	4
Great Lakes:						
Duluth, Minn	0	0	0	0	2	2
Kansas River:						
DeSot ·, Kans	1	2	3	4	16	20
Little Miami River:						
Cincinnati, Ohio	0	1	1	1	7	8
Mississippi River:						
St. Paul, Minn	0	2	2	1	13	14
Missouri River:						
Williston, N. Dak	4	4	8	20	13	33
Bismark, N. Dak	<1	3	3	1	9	10
St. Joseph, Mo	1	4	5	2	20	22
Missouri City, Mo	9	4	13	31	19	50
Monongahela River:						
Pittsburgh, Pa	0	0	0	0	3	3
North Platte River:						
Henry, Nebr	1	28	29	5	31	36
Ohio River:						
Cincinnati, Ohio	1	0	1	1	8	9
Cairo, Ill	3	0	3	13	7	20
Platte River:						
Plattsmouth, Nebr	0	5	5	2	19	21
Potomac River:						
Washington, D. C	0	0	0	1	3	4
Rainy River:						
International Falls, Minn	0	0	0	1	8	9
Red River, North:						
Grand Forks, N. Dak	0	0	0	3	18	21
South Platte River:						
Julesburg, Colo	4	34	38	14	63	77
Yellowstone River:						
Sidney, Mont	0	5	5	2	23	25
Maximum	9	34	38	34	63	77
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network April 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during April 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

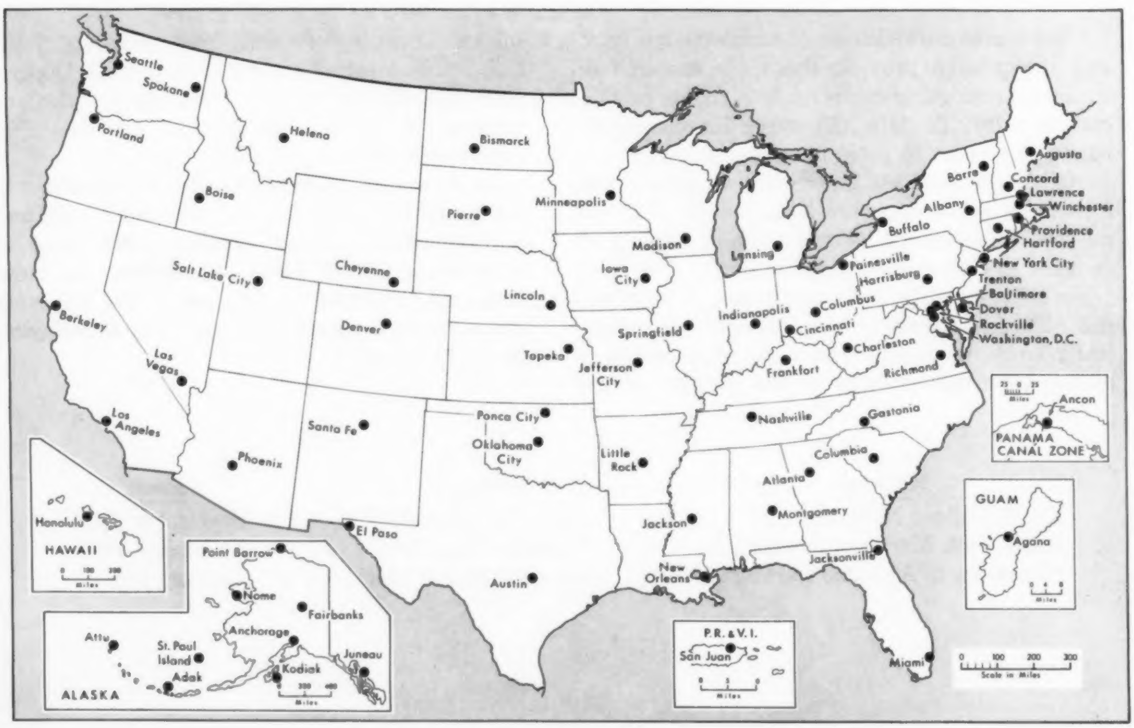

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, April 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	5	0	2	Feb 69	5	83	5	83	23
Alaska:	Adak	4	2	1	1	Feb 69	(c)				
	Anchorage	3	0	0	0	Oct 68	(c)				
	Attu Island	15	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	21	0	0	0	Dec 68	15	148	13	122	0
	Kodiak	2	0	0	0	Jan 69	(c)				
	Nome	(b)			0	May 69	(c)				
	Point Barrow	30	0	0	0	Apr 69	(c)				
	St. Paul Island	16	1	1	1	June 69	(c)				
Ariz:	Phoenix	21	10	2	5	Dec 68	(c)				
Ark:	Little Rock	9	2	0	1	Aug 69	(c)				
Calif:	Berkeley	22	1	0	0	Jan 69	6	64	6	64	0
	Los Angeles	22	2	0	0	May 69	(c)				
C.Z:	Ancon	16	0	0	0	Jan 69	(c)				
Colo:	Denver	20	8	0	2	Jan 69	2	10	(d)		
Conn:	Hartford	20	0	0	0	Nov 68	9	73	9	73	0
Del:	Dover	21	2	0	0	July 69	(c)				
D.C.:	Washington	4	2	0	1	Apr 69	(c)				
Fla:	Jacksonville	22	1	0	0	Aug 69	5	110	4	105	93
	Miami	17	0	0	0	Nov 68	7	102	7	102	0
Ga:	Atlanta	22	2	1	1	June 69	2	57	2	57	40
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	26	1	0	0	Mar 69	2	30	(d)		
Idaho:	Boise	20	3	1	2	Mar 69	4	46	3	40	6
Ill:	Springfield	23	3	0	2	Apr 69	3	70	0	0	(c)
Ind:	Indianapolis	21	2	0	1	June 69	8	118	8	118	133
Iowa:	Iowa City	20	3	0	1	Jan 69	5	104	5	104	0
Kans:	Topeka	19	3	0	1	Aug 69	6	119	6	119	2
Ky:	Frankfort	8	1	1	1	Apr 69	(c)				
La:	New Orleans	19	2	0	0	Apr 69	8	147	(d)		
Maine:	Augusta	21	1	0	0	May 69	9	109	9	109	0
Md:	Baltimore	21	2	0	1	Nov 68	6	53	6	53	31
	Rockville	12	1	0	0	Mar 69	(c)				
Mass:	Lawrence	19	2	0	0	July 69	6	87	6	87	2
	Winchester	22	2	0	0	Feb 69	8	98	8	98	0
Mich:	Lansing	22	3	1	2	Mar 69	9	64	9	64	117
Minn:	Minneapolis	20	1	0	0	July 69	4	48	4	48	5
Miss:	Jackson	16	1	0	0	May 69	4	243	4	243	41
Mo:	Jefferson City	21	2	0	0	June 69	8	103	8	103	0
Mont:	Helena	21	9	0	3	Feb 69	4	4	4	4	3
Nebr:	Lincoln	19	4	1	2	June 69	3	91	3	91	54
Nev:	Las Vegas	17	3	0	1	Nov 68	(c)				
N.H.:	Concord	20	2	0	0	Apr 69	(c)				
N.J:	Trenton	21	2	0	1	May 69	(c)				
N. Mex:	Santa Fe	11	2	0	1	Feb 69	2	43	1	21	0
N.Y:	Albany	18	1	0	1	June 69	8	59	8	59	50
	Buffalo	22	1	0	0	Jan 69	(c)				
	New York City	19	0	0	0	Feb 69	(c)				
N.C:	Gastonia	16	8	1	3	Jan 69	5	78	(d)		
N. Dak:	Bismarck	21	3	0	1	Apr 69	2	24	2	24	0
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	18	2	0	1	May 69	8	92	1	34	0
	Painesville	20	1	0	1	Nov 68	14	97	14	97	28
Okla:	Oklahoma City	18	2	0	1	Mar 69	3	34	3	34	0
	Ponca City	21	5	0	1	Nov 68	7	62	7	62	6
Ore:	Portland	21	2	0	1	June 69	13	75	13	75	4
Pa:	Harrisburg	6	1	0	1	June 69	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	23	1	0	0	Mar 69	(c)				
S.C:	Columbia	20	2	0	0	Feb 69	5	106	5	106	25
S. Dak:	Pierre	13	6	1	3	Dec 68	(c)				
Tenn:	Nashville	(b)				Mar 69	(c)				
Tex:	Austin	19	5	0	3	July 69	6	87	(d)		
	El Paso	(b)				Apr 69	(c)				
Utah:	Salt Lake City	32	2	0	1	May 69	5	30	5	30	4
Vt:	Barre	20	2	0	1	Aug 69	9	63	9	63	0
Va:	Richmond	21	0	0	0	Aug 69	7	94	7	94	16
Wash:	Seattle	15	0	0	0	Aug 69	7	55	(d)		
	Spokane	22	2	0	1	July 69	(e)				
W. Va:	Charleston	23	2	0	1	Feb 69	12	69	12	69	18
Wisc:	Madison	23	1	0	0	Aug 69	9	81	9	81	50
Wyo:	Cheyenne	21	7	0	3	Nov 68	3	22	3	22	21
Network summary		1,219	10	0	1		6	78	6	77	21

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

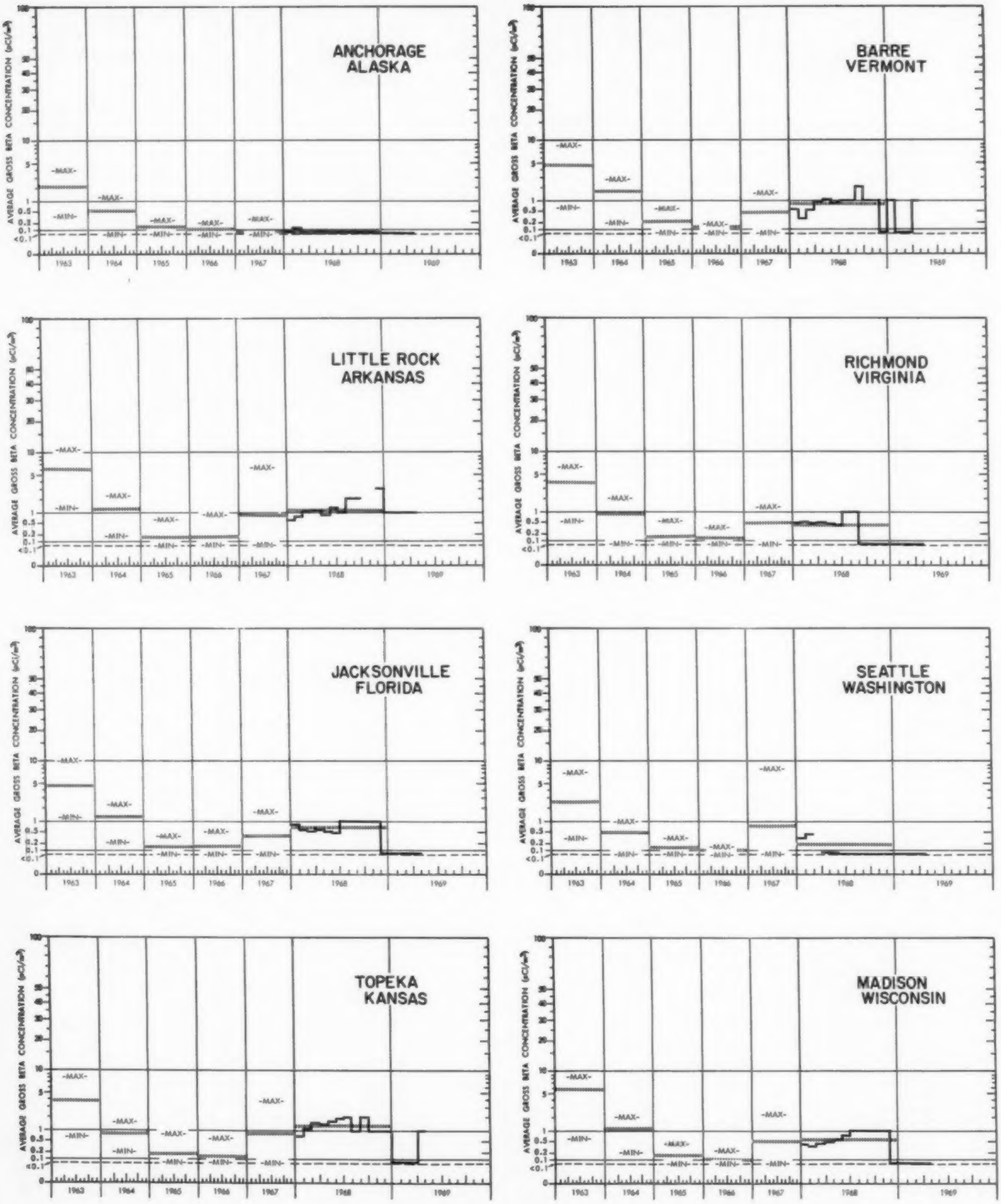

Figure 2. Monthly and yearly profiles of beta radioactivity in air, Radiation Alert Network, 1963–April 1969

2. Canadian Air and Precipitation Monitoring Program[1], April 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the July 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the may 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for April 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	30	0.3	0.0	0.1	34	1.9
Coral Harbour	29	.2	.0	.1	65	.2
Edmonton	30	.3	.0	.1	156	3.6
Ft. Churchill	29	.2	.0	.1	28	.8
Ft. William	10	.2	.1	.1	126	4.4
Fredericton	29	.2	.0	.1	40	3.0
Goose Bay	30	.1	.0	.1	31	1.2
Halifax	30	.2	.0	.1	50	4.9
Inuvik	30	.1	.0	.1	150	.7
Montreal	30	.2	.1	.1	53	5.2
Moosonee	30	.3	.0	.1	36	.5
Ottawa	30	.3	.0	.1	58	7.1
Quebec	30	.2	.0	.1	53	5.0
Regina	30	.2	.0	.1	87	1.9
Resolute	28	.2	.1	.1	71	.3
St. John's, Nfld	29	.2	.0	.1	27	2.9
Saskatoon	30	.2	.1	.1	228	2.4
Saulte Ste Marie	30	.2	.0	.1	54	5.0
Toronto	30	.2	.0	.1	66	4.7
Vancouver	30	.2	.0	.1	60	6.3
Whitehorse	30	.1	.0	.0	80	.3
Windsor	28	.2	.0	.1	69	6.7
Winnipeg	30	.3	.0	.1	112	2.8
Yellowknife	30	.1	.0	.1	19	.4
Network summary	692	0.3	0.0	0.1	73	3.0

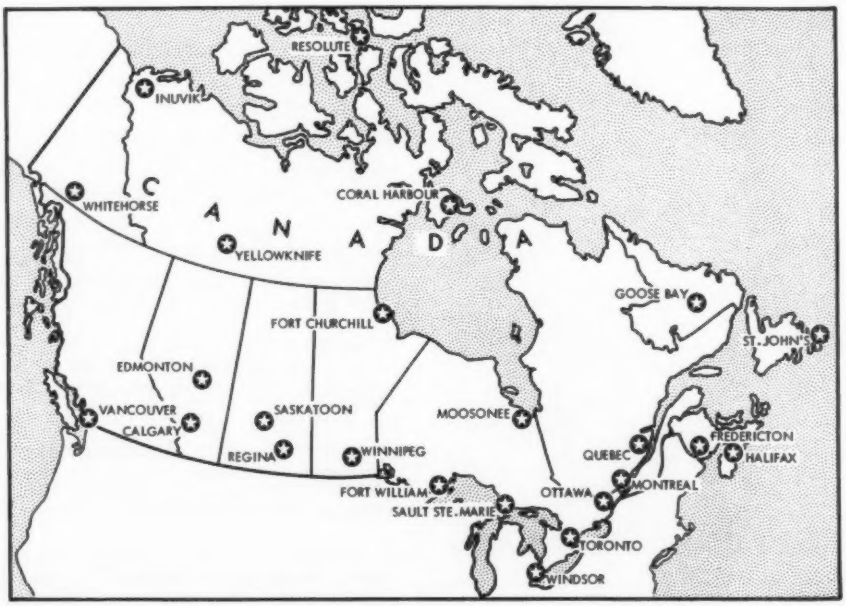

Figure 3. Canadian air and precipitation stations

3. Pan American Air Sampling Program April 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. It should be noted that a new sampling station has been established in Cuenca, Ecuador. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports.* The April 1969 air monitoring results from the participating countries are given in table 3.

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, April 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	0.43	0.12	0.31
Bolivia: La Paz	15	.57	.07	.21
Chile: Santiago	30	.62	.36	.50
Colombia: Bogata	17	.48	.16	.30
Ecuador: Cuenca	4	.24	.22	.23
Guayaquil	17	.36	.02	.22
Quito	18	.23	.17	.22
Guyana: Georgetown	16	.89	.03	.59
Jamaica: Kingston	18	.49	.06	.25
Peru: Lima	NS			
Venezuela: Caracas	18	1.32	.07	.36
West Indies: Trinidad	17	.32	.14	.21
Pan American summary	185	1.32	0.02	0.33

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Feed Materials Production Center, and the National Reactor Testing Station.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center[2] July-December 1968

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal

Figure 1. Area map of Feed Materials Production Center

[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1968, Summary Report for 1968" (NLCO-1036).

of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project an environmental survey program has been established which consists of water, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and

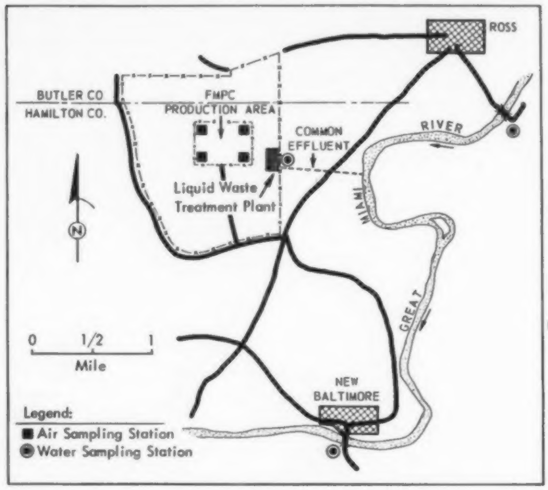

Figure 2. Air and water sampling stations, Feed Materials Production Center

settling. The clear water from the sump is pumped to the river The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewage system and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioact:ve contami-

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, July–December 1968

Location	Number of samples	Uranium concentration (pCi/m^3)[a]			Total radioactivity (pCi/m^3)[b]		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	5	0.1	<0.1	<0.1	0.2	<0.1	0.1
Northwest	26	1.0	< .1	.1	2.1	< .1	.3
Northeast	26	.5	< .1	.2	.9	.1	.4
Southeast	26	1.0	< .1	.2	1.9	< .1	.4
All onsite samples	83			.2			.4
Offsite:							
0–2 miles from FMPC	26	.3	< .1	< .1	.8	< .1	.2
2–4 miles from FMPC	32	.2	< .1	< .1	.5	< .1	.2
4–8 miles from FMPC	33	.4	< .1	< .1	.6	< .1	.1
8–12 miles from FMPC	16	.1	< .1	< .1	.3	< .1	.2
All offsite samples	107			.1			.2

[a] AEC radiation protection standard—2 pCi/m^3.
[b] AEC radiation protection standard—100 pCi/m^3.

nant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream; a continuous sample is taken for a 24-hour period and random samples are analyzed each week. The results of the FMPC water monitoring program for July–December 1968 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	August 1968
January–June 1968	April 1969

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center July–December 1968

Location	Number of samples	Uranium concentration (pCi/liter)[a]			Total radioactivity (pCi/liter)[b]		
		High	Low	Average	High	Low	Average
Sewer outfall	184	20	<10	<10	70	<10	10
Upstream from outfall	21	10	<10	7	60	<10	20
Downstream from outfall	25	50	<10	10	90	10	30

[a] AEC radiation protection standard—20,000 pCi/liter.
[b] AEC radiation protection standard— 3,000 pCi/liter.

2. National Reactor Testing Station[3] January-June 1968

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1968 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the levels defined as thresholds of concern by the Federal Radiation Council (FRC). The radiation protection standards used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium-226 or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate radioactivity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water and milk are collected routinely at stations shown in figure 3. The results of the analyses performed on the air, water, and milk samples are shown in table 3.

[3] Summarized from "Environmental Monitoring Report No. 22, January–June 1968," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory, National Reactor Testing Station.

Water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the groundwater table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples provide adequate information on the underground water leaving the NRTS. A total of 12 offsite underground water samples and two surface water samples were collected during this report period.

Onsite samples are collected on a biweekly basis and offsite samples semiannually. A total of 218 water samples were collected onsite for the first 6 months of 1968.

Air monitoring

The filters from onsite continuously operated samplers are collected and analyzed weekly. These filters are analyzed for gross alpha, gross beta, and iodine-131 radioactivity. A sampler with filters identical to those used for onsite monitoring is located at Idaho Falls which indicates the radioactivity level from only natural and nuclear weapon fallout material. The onsite and Idaho Falls air monitoring stations are shown in figure 3. The monitoring results from Idaho Falls are listed in tables 3 as the offsite station.

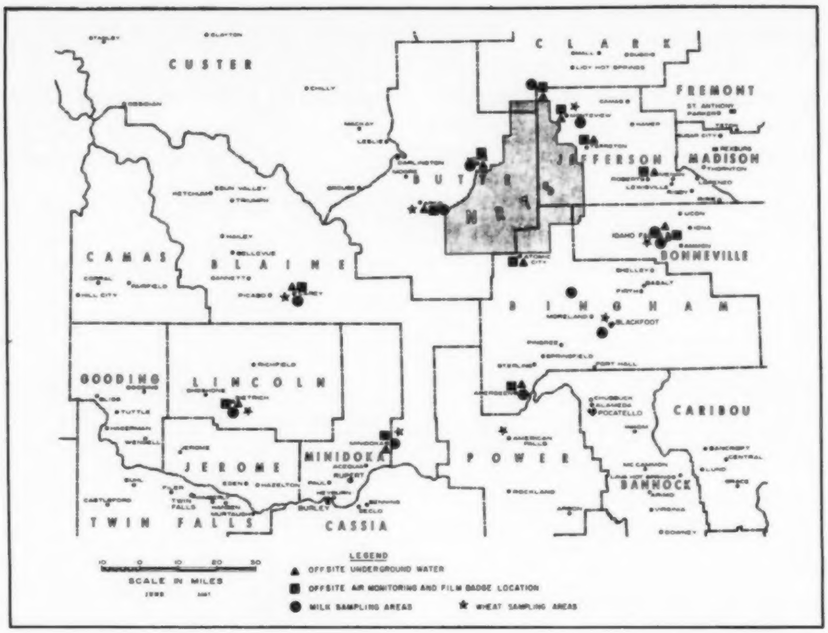

Figure 3. Environmental monitoring stations, National Reactor Testing Station

Offsite milk monitoring

Offsite milk samples are collected routinely and analyzed for iodine-131 and strontium-90 radioactivity. During the first 6 months of 1968 a total of 90 milk samples were analyzed. The milk sample results are given in table 3.

Gamma radiation levels

Semiannual measurements (table 3) of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 11 offsite locations during January-June 1968.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100-150 mR/yr. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Recent coverage in *Radiological Health Data and Reports.*

Period	Issue
January–June 1967	March 1968
Calendar year 1967	October 1968

Table 3. Environmental monitoring data for the National Reactor Testing Station, January–June 1968

Type of sample and units	January–June 1968						
	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC standards
Onsite production well water, (pCi/liter)	22	Biweekly	Alpha	3	9	<3	3,000
			Beta	5	36	<6	3,000
Offsite underground water, (pCi/liter)	12	Semiannual	Alpha	3	4	4	100
			Beta	5	<5	<5	100
Surface water, (pCi/liter)	2	Semiannual	Alpha	3	4	4	100
			Beta	5	<5	<5	100
Onsite air, (pCi/m³)	8	Continuous	Alpha	0.001	0.005	0.002	1
			Beta	.003	3.17	.65	300
			Iodine-131	.09	5.16	.13	9,000
Offsite air, (pCi/m³)	1	Continuous	Alpha	.001	.007	.002	0.04
			Beta	.003	1.40	.65	10
			Iodine-131	.09	.16	.02	100
Offsite milk, (pCi/liter)	12	Monthly	Iodine-131	20	20	20	100
			Strontium-90	1	10	<6	200
Offsite area monitoring badges, (mR)	11	Semiannual	Gamma	10	145	48	170/yr

Reported Nuclear Detonations, July 1969

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20-200 kilotons TNT equivalent) were conducted underground on July 16, 1969 by the Atomic Energy Commission at its Nevada Test Site.

On July 22, 1969, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20-200 kilotons TNT equivalent).

Erratum

In the report "Preliminary Results of Surveys of 5,263 Medical X-ray Facilities, 1962–1967" by the Bureau of Radiological Health, which appeared in the June 1969 issue of *Radiological Health Data and Reports*, the sixth line in the first paragraph on page 235 should be corrected to read ". . . 1962 to 1967. Seven States, 1 territory and the. . . .".

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL SURVEILLANCE AROUND A NUCLEAR FUEL REPROCESSING INSTALLATION, 1965–1967. *William J. Kelleher. Radiological Health Data and Reports, Vol. 10, August 1969*, pp. 329-339

A summary report of environmental surveillance around a nuclear fuel reprocessing plant is presented. This report includes data obtained before and after the plant began operations in April 1966. Media monitored included air and milk supplies in the surrounding area; liquid wastes; local watersheds and streams; silt, deer, and fish in the plant perimeter area. Data obtained through 1967 indicate that the discharges from the plant stack have not produced environmental effects from particulate beta-particle emitters or iodine-131 that might constitute a public health hazard. Surveillance of the streams showed greater concentration of strontium-90 during the fall and winter of 1966–1967 than in the latter part of 1967. Silt removed more cesium-137 than strontium-90; most of the latter was in the dissolved state. The ratio of cesium-137 to cesium-134 (cesium-134 is indicative of spent fuel) in the wastes was about 4 or 5 to 1. The levels of radioactivity in deer and fish were sufficiently high to require careful evaluation of the public health significance.
KEYWORDS: Air, cesium-134, cesium-137, deer, environmental surveillance, fish, iodine-131, milk, New York State, nuclear fuel reprocessing plant, radioactivity, silt, strontium-90, water.

A 5-YEAR SUMMARY OF THE REGULATORY CONTROL OF RADIOACTIVE MATERIAL IN ARKANSAS. *E. F. Wilson and D. D. Snellings, Jr. Radiological Health Data and Reports, Vol. 10, August 1969*, pp. 341-345.

The Arkansas State Department of Health, Division of Radiological Health, in assuming the regulatory control of radioactive material on July 1, 1963, instituted a program of licensing and inspection of all users of regulated material with the ultimate goal of preventing, if possible, or reducing to an acceptable level, the exposure of ionizing radiation.

This report is a summary of regulatory activities of the Division of Radiological Health from 1964 through and including 1968. The early (1964) regulatory inspections did not include sufficient data pertaining to the occupational exposure of individuals to radiation; however, the noted deficiencies of records and radiation safety are well documented. In early 1967, the Division of Radiological Health prepared all previous data for electronic data processing, and currently all regulatory inspections, as well as licensing activities, are prepared for electronic data processing on a routine basis.
KEYWORDS: Arkansas, compliance, ionizing radiation, licenses, occupational exposure, radium.

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August 1969

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